Title: *NASA's M&S Accreditation Process Plan and Specification for Space Exploration*, Dave O'Neil, Q-Tec, Inc. and Joseph Hale, NASA MSFC

Abstract:

NASA's Exploration Systems Mission Directorate (ESMD) is implementing a management approach for modeling and simulation (M&S) that will provide decision-makers information on the model's fidelity, credibility, and quality. This information will allow the decision-maker to understand the risks involved in using a model's results in the decision-making process. This presentation will discuss NASA's overall approach to achieving formal accreditation of its models or simulations supporting space exploration. The development of a formal Accreditation Plan is a key component in the preliminary activities for modeling and simulation (M&S) assessment. This presentation will describe NASA's process for identifying risks associated with M&S use and the associated M&S assessments that will dictate the level of data certification and M&S verification and validation (V&V) activities required to support the decision-making process. The M&S Accreditation Plan and Report templates for ESMD will also be illustrated.

Integrated Modeling and Simulation

NASA's M&S Accreditation Process Plan and Specification for Space Exploration

David O'Neil/QTEC
Joe Hale/NASA/MSFC

Pre-decisional DRAFT

Integrated Modeling and Simulation

NASA Guidance Documents

- ESMD-IM&S-XXXX, ESMD Modeling and Simulation Management **(Draft)**

- ESMD-IM&S-XXXX, Modeling and Simulation Glossary **(Draft)**

- ESMD-IM&S-XXXX, ESMD IM&S Implementation Plan **(Draft)**

- ESMD-IM&S-XXXX, ESMD IM&S Concept of Operations **(Draft)**

- ESMD-IM&S-XXXX, ESMD Verification, Validation and Accreditation Policy **(Draft)**

- ESMD-IM&S-XXXX, ESMD Accreditation Plan and Accreditation Report Process and Specification **(Draft)**

- ESMD-IM&S-XXXX, ESMD IM&S Risk Management Plan **(Draft)**

Pre-decisional DRAFT

The Core Process of IM&S VV&A

VERIFICATION

The process of determining that a model [or simulation] implementation and its associated data accurately represents the developer's conceptual description and specifications... *Did we build that thing right?*

"It works as I thought it would."
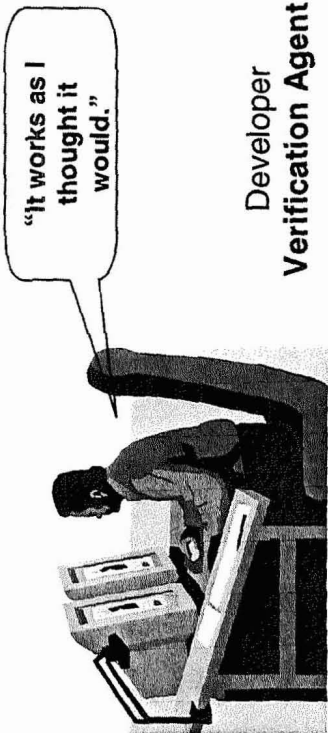
Developer
Verification Agent

VALIDATION

The process of determining the degree to which a model [or simulation] and its associated data provides an accurate representation the real world from the perspective of the intended uses of the model or simulation... *Did we build the right thing?*

"It looks just like the real thing."

Functional Expert
Validation Agent

ACCREDITATION

The official certification that a model or simulation or federation of models and simulations and its associated data is acceptable for use for a specific purpose... *Should it be used?*

"It suits my needs."

Requester/User
Accreditation Agent

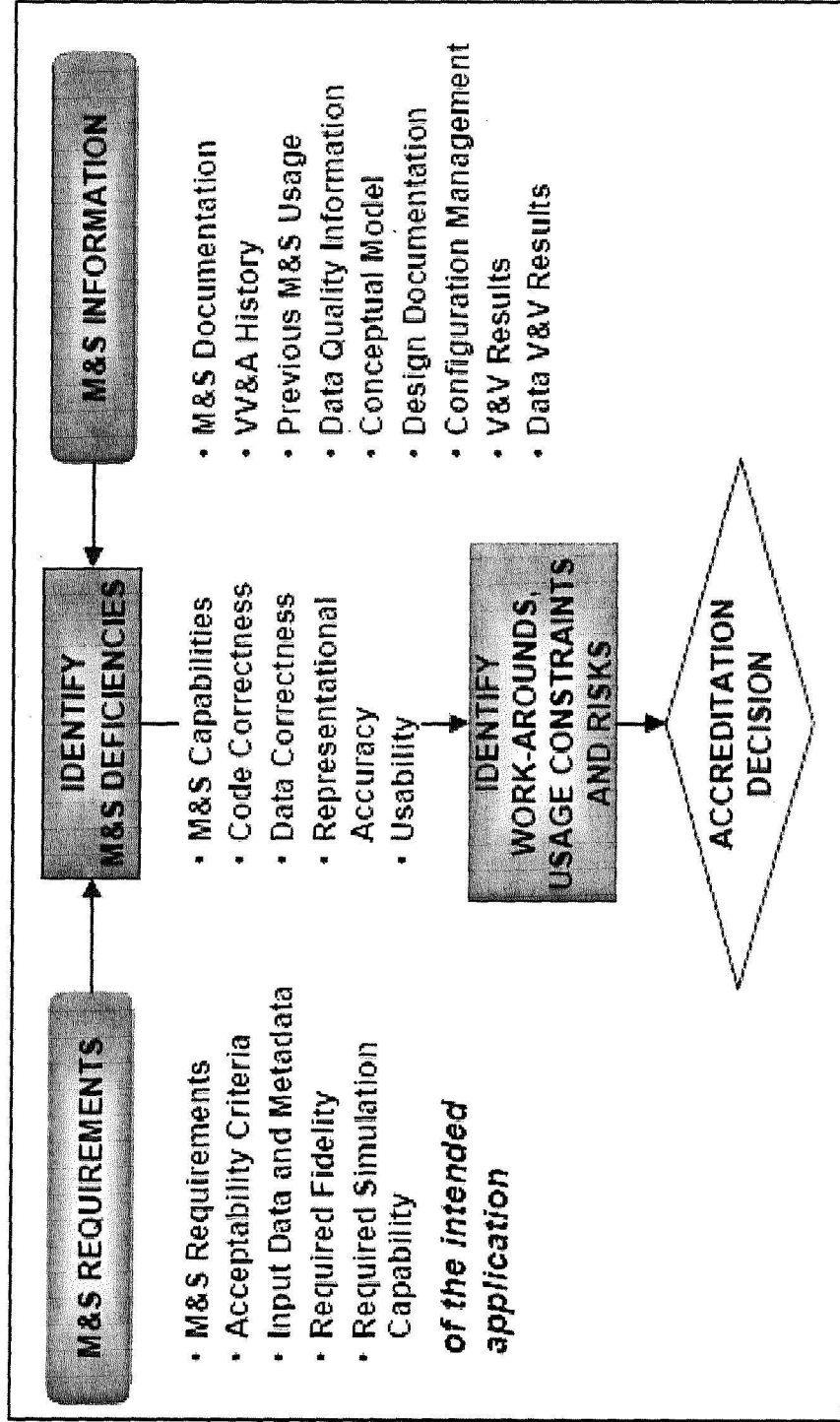*An underlying implicit principle – Creditability – Should it be trusted?*

Integrated Modeling and Simulation

- *Why is VV&A performed?*

- To determine whether a model or simulation or federation should be used in a given situation, its *credibility* should be established by evaluating *fitness* for the intended use.

- Verification, validation, and accreditation (VV&A) are three interrelated but distinct processes that gather and evaluate evidence to determine, based on the simulation's intended use, the simulation's capabilities, limitations, and performance relative to the real-world objects it simulates. The decision to use the simulation will depend on the simulation's capabilities and correctness, the accuracy of its results, and its usability in the specified application.

Integrated Modeling and Simulation

M&S INFORMATION

- M&S Documentation
- VV&A History
- Previous M&S Usage
- Data Quality Information
- Conceptual Model
- Design Documentation
- Configuration Management
- V&V Results
- Data V&V Results

M&S REQUIREMENTS

- M&S Requirements
- Acceptability Criteria
- Input Data and Metadata
- Required Fidelity
- Required Simulation Capability

of the intended application

IDENTIFY M&S DEFICIENCIES

- M&S Capabilities
- Code Correctness
- Data Correctness
- Representational Accuracy
- Usability

IDENTIFY WORK-AROUNDS, USAGE CONSTRAINTS AND RISKS

ACCREDITATION DECISION

A Practical Accreditation Concept

Integrated Modeling and Simulation

- Roles and Responsibilities

  - **Accreditation Sponsor** – The organization with the responsibility for accrediting a model, simulation, or federation of models and/or simulations for a specific use or series of uses.

  - **Accreditation Agent** - The individual, group, or organization designated by the accreditation sponsor to conduct an accreditation assessment for a M&S application.

  - **V&V Agent** – the role responsible for providing evidence of the simulation's fitness for the intended use by ensuring that all the necessary V&V tasks are properly carried out

  - **User** – the role responsible for defining the problem (e.g., M&S requirements, measures, acceptability criteria, referent), determining how to solve it, and making the accreditation decision

  - **M&S Program Manager** – the role responsible for managing the development or modification of the simulation for the intended use, when needed

  - **Developer** – the role responsible for providing technical expertise regarding simulation capabilities, for preparing data for use in the simulation, and for making code modifications and developing new code, when needed

  - **M&S Proponent** – the role responsible for managing the legacy simulation throughout its lifecycle, including configuration management, application, and maintenance, and for approving all modifications to the authorized version of the simulation

Integrated Modeling and Simulation

- Accreditation Policy

  - A systematic plan of risk-based VV&A is required to accredit M&S.

  - A simulation used to support major decision-making organizations and processes will be accredited specifically for that usage by the application sponsor
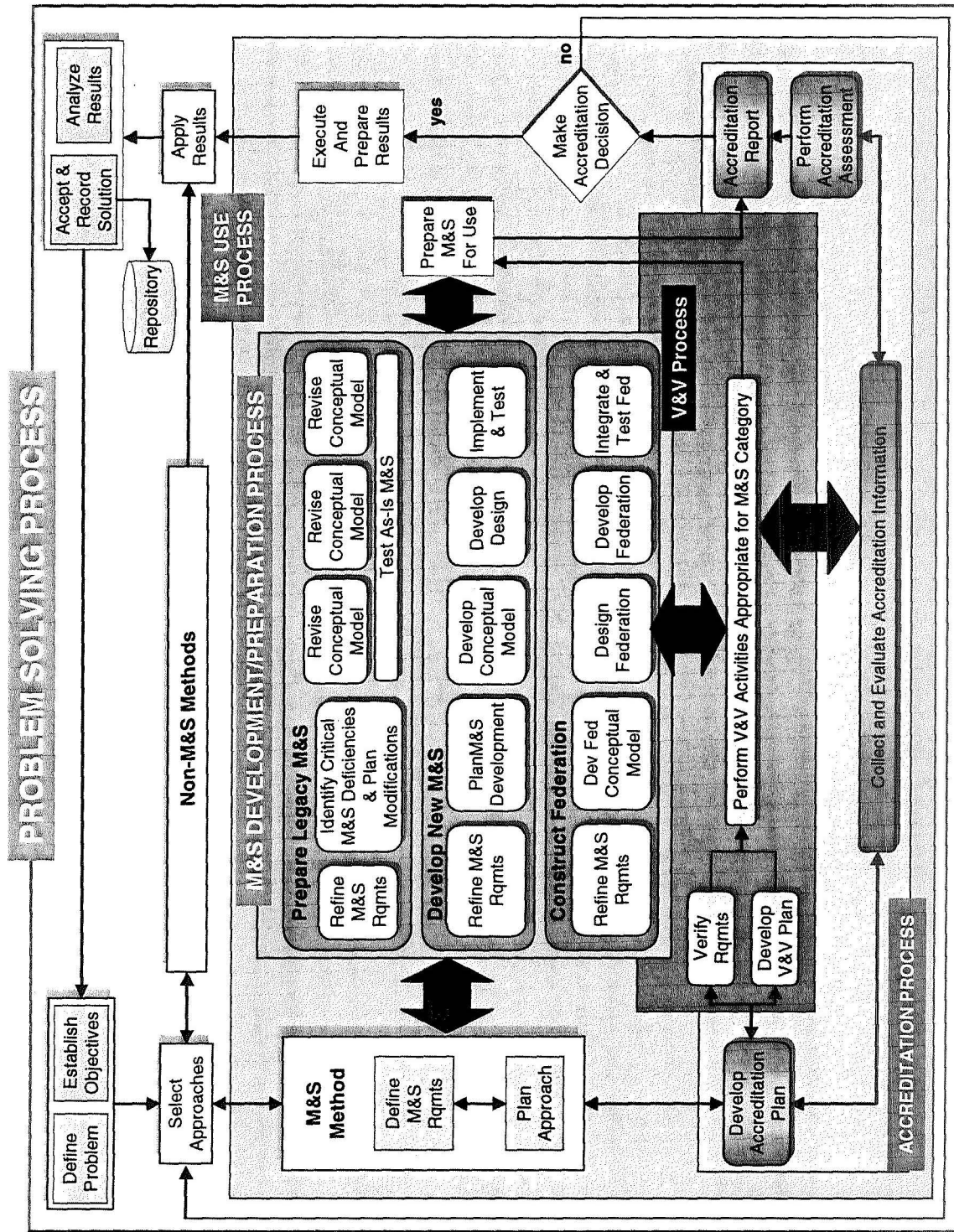
Integrated Modeling and Simulation

- A simulation's fitness for purpose is dependent on four key fitness factors:

  – **Capability** -- what the simulation can do in terms of functional representations, behaviors, relationships, and interactions

  – **Correctness** -- error-free code; appropriate, authoritative input data

  – **Accuracy** -- how closely the simulation results correspond to the intended view of reality (i.e., the referent)

  – **Usability** -- the existence and sufficiency of user-support features (e.g., manuals, training) which will enable the User to properly execute the simulation and analyze and/or employ the results
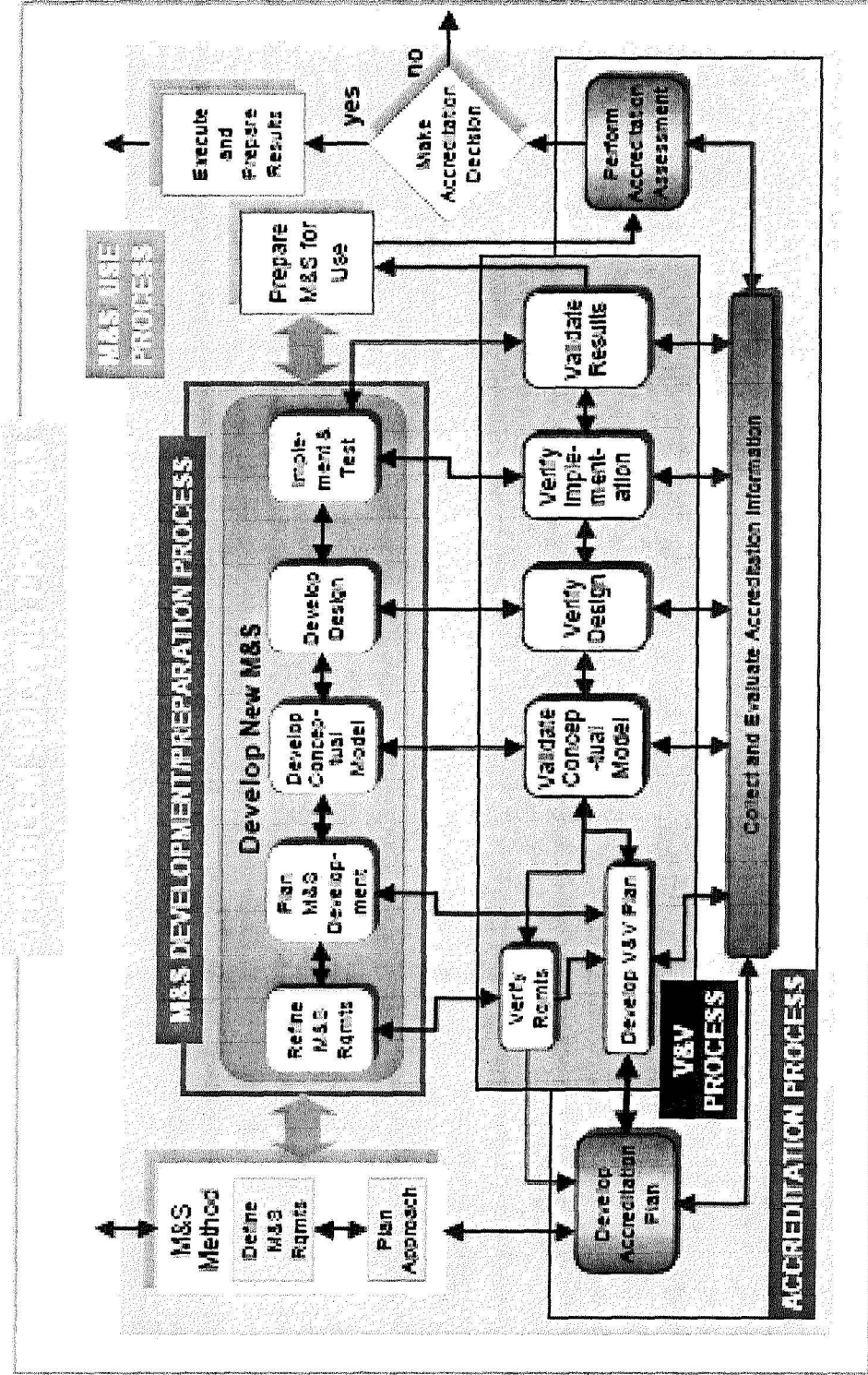
Integrated Modeling and Simulation

The Overall Problem Solving Process
Pre-decisional DRAFT

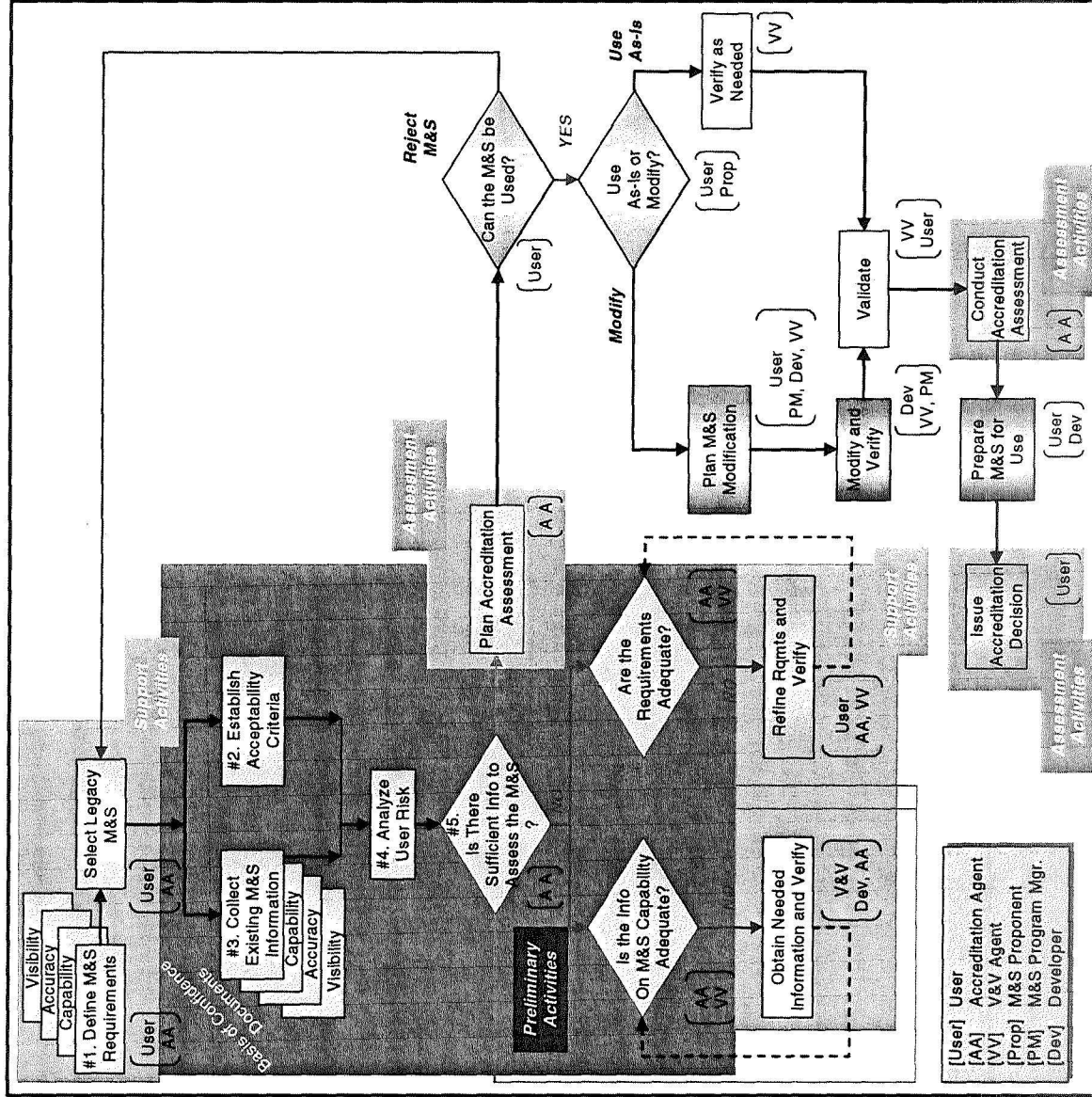# Integrated Modeling and Simulation

M&S Development/Preparation Process for New M&S

Pre-decisional DRAFT

Integrated Modeling and Simulation

Accreditation Agent Activities in the VV&A of a Legacy Simulation
Pre-decisional DRAFT

Integrated Modeling and Simulation

- Risk Assessment

  - **Development risks** – risk associated with the modification of the legacy simulation due to
    - compromises made because the simulation does not exactly meet the needs of the intended application (e.g., inadequate representations, insufficient accuracy)
    - potential problems in addressing the technical, scheduling, or resourcing aspects of the modification effort

  - **Operational risks** -- risk arising from using simulation results that are incorrect and risks arising from not believing simulation results that are correct

  - **Inherited risks** – risk arising from effects carried forward from previous simulation development or usage, such as effects resulting from
    - undocumented assumptions, limitations, and constraints
    - errors and defects that were either undetected or considered insignificant in previous applications

Pre-decisional DRAFT

Integrated Modeling and Simulation

Accreditation Plan

- Influences the entire V&V effort

- Identifies what information is needed to conduct the accreditation assessment

- Determines the scope of the accreditation effort

- Is based on risk associated with using the simulation for the intended purpose

- Establishes priorities for the V&V effort

Pre-decisional DRAFT

Integrated Modeling and Simulation

ACCREDITATION PLAN

Accreditation Plan Executive Summary

1. **Purpose** — Why is the use of M&S required?
   1.1 System / Process Modeled — What is the system or process being modeled?
   1.2 Concept of Operations — What is the con ops for how the system will be used?
   1.3 Use of M&S — How will M&S be applied in the program?
   1.4 M&S Category Definition (Legacy, New, Federation, Data Model)

2. **Background** — Why has this M&S been chosen?
   2.1 References — What references justify the use of this M&S?
   2.2 Definitions — What terms must be defined?
   2.3 Constraints — What constraints have motivated the use of this M&S?

3. **M&S Intended Use** — What is the intended use of this M&S?
   3.1 Objective — What objectives will the M&S be used to fulfill?
   3.2 M&S Requirements — What requirements must the M&S meet to be credible?
   3.3 M&S Limitations — What are the known /anticipated limitations of the M&S?
   3.4 M&S Risk Management & Assessment — What risks are associated with this M&S?

4. **Acceptability Criteria** — What acceptability criteria must the M&S fulfill?
   4.1 Acceptability Issues and Criteria — What issues must the V&V process address?
   4.2 Acceptability Criteria Measures and Metrics — What measures and metrics will be used?

5. **M&S Description** — What does the M&S look and feel like?
   5.1 M&S History & Use — What is the history of the M&S use?
   5.2 M&S Development — How is/was the M&S developed?
   5.3 M&S Variables — What are the M&S variables?
   5.4 M&S Inputs/Outputs — What are the necessary inputs of the M&S?
   5.5 Configuration Management — What activities ensure CM of the M&S?

Integrated Modeling and Simulation

ACCREDITATION PLAN (Continued)

6. Accreditation Resources — What resources are required for the accr?
    6.1 Accreditation Funding — What tasks will resources support?
    6.2 Accreditation Timeline — When will accreditation be completed?

7. Accreditation Issues — What issues remain unresolved?

8. Key Participants — Who are the points-of-contact for the M&S?
    8.1 Accreditation Participants
        8.1.1 Accreditation Authority
        8.1.2 Accreditation Agent
        8.1.3 Accreditation Team

    8.2 V&V Participants
    –   8.2.1. M&S Proponent
    –   8.2.2. Accreditation Authority
    –   8.2.3. Authoritative Data Source
    8.3. M&S Development Participants
    –   8.3.1. M&S Developer
    8.4 M&S User Participants
    –   8.4.1. Milestone Decision Authority
    –   8.4.2. Program Office
    –   8.4.3. Project Leader
    –   8.4.4. Testers

Pre-decisional DRAFT

Integrated Modeling and Simulation

ACCREDITATION PLAN (Continued)

Accreditation Methodology   How will the M&S be accredited?

9. Accreditation Methodology

9.1. Assessment Planning Factors

9.1.1. Assessment of Simulation Capability

9.1.2. Assessment of Simulation and Data Correctness

9.1.3. Assessment of Simulation Accuracy

9.1.4. Assessment of Simulation Usability

9.1.5. Assessment of the Scope and Depth of the Evidence

9.2. Assessment Activities

9.2.1. Assessment of the Adequacy of the Existing or Planned Documentation in Light of Expected Operational Risk Levels

9.2.2. Assessment of the Ability of Planned and/or Executed V&V Activities to Provide the Necessary Information in Light of Expected Operational Risk Levels

9.2.3. Assessment of the Ability of the Simulation to Meet M&S Requirements in Light of Expected Operational Risk Levels

9.3. Verification and Validation Planning Support

9.3.1. Tasks to Verify and Validate Existing Parts of the Simulation to Obtain Missing Information

9.3.2. Data V&V Tasks to Ensure Both Data Previously Used in the Simulation and New Data are Appropriate for the Intended Use

9.3.3. Tasks to Verify and Validate any Modifications Involved

10. Accreditation Plan Summary   What are the salient points of the acc?

Integrated Modeling and Simulation

Assessment Planning Factors

Simulation Capability

ISSUE: Does the simulation do what it needs to do?

Information	Sources	What is needed when risk is . . .		
		Low	Medium	High
Functional Breakdown and Description of Simulation	• User documentation	Any Source	Required	Required
	• Design documentation		Any one	Either one
	• Simulation conceptual model			
List of Limitations Due to Assumptions and Errors	• Design documentation, user documentation, Configuration Management (CM) database, V&V reports	Desirable		Required

Software Correctness

ISSUE: How much confidence do you have in the correctness of the software?

Information	Sources	What is needed when risk is . . .		
		Low	Medium	High
Simulation Development Process Description	• SW Development Plan (SDP) or Configuration Management Plan (CMP)	Either one	Required	Required
Simulation Development Resources Description	• SDP, management plans, developers, M&S proponent, SEI Capability Maturity Model (CMM) evaluation reports		Any two	Required
	• Standard M&S documentation, CM histories			
Simulation Development Artifacts and Products	• Model documentation [Software User's Manual (SUM), Software Programmer's Manual (SPM)]			Any two
	• Design documentation (documented requirements and simulation conceptual model)			

Pre-decisional DRAFT

Integrated Modeling and Simulation

Assessment Planning Factors (continued)

- Similar charts for
  - Overall Data Correctness
  - Data Correctness, Database Level
  - Simulation Usability

Integrated Modeling and Simulation

Accreditation Report

- Section 1: Introduction

- Section 2: Capability

- Section 3: Accuracy (code, data, output)

- Section 4: Usability (support available to facilitate accurate and efficient use of the model)

Pre-decisional DRAFT

Integrated Modeling and Simulation

ACCREDITATION REPORT

Foreword

Table of Contents

Acronyms and Abbreviations

References

Executive Summary

1. Accreditation Support Package Introduction

   1.1 Overview of Accreditation Process

   1.2 Accreditation Support Information

      1.2.1   Capability

      1.2.2   Accuracy

      1.2.3   Usability

2. Capability

   2.1 Model Description

   2.2 Functional Capabilities

   2.3 Development History

   2.4 Assumptions and Limitations

      2.4.1 Assumptions

      2.4.2 Limitations

   2.5 Implications for Model Use

Pre-decisional DRAFT

Integrated Modeling and Simulation

ACCREDITATION REPORT (Continued)

3. Accuracy

   3.1 Software Accuracy

   3.1.1 Software Verification Results

   3.1.2 Software Development and Configuration Management Environment

   3.1.3 Software Quality Assessment

   3.1.4 Implications for Model Use

   3.2 Data Accuracy

   3.2.1 Simulation Input Data

   3.2.2 Data Transformations

   3.2.3 Implications for Model Use

   3.3 Output Accuracy

   3.3.1 Sensitivity Analyses

   3.3.2 Benchmarking Validation

   3.3.3 Face Validation

   3.3.4 Results Validation

   3.3.5 Implications for Model Use

Integrated Modeling and Simulation

ACCREDITATION REPORT (Continued)

4. Usability

    4.1 Documentation

    4.2 User Support

    4.3 Usage History

    4.4 Implications for Model Use

Appendix A: Expanded Description of Accreditation Process

Appendix B: Terminology

Integrated Modeling and Simulation

CONCLUSION

- The Accreditation Plan is developed as a key component in the preliminary activities for M&S assessment.

- The Accreditation Report contains all the relevent data that contributes to and supports an accreditation decision.

- Accreditation is for a specific intended use of a M&S. Use of the same M&S for a different intended use requires another accreditation.

- The accreditation process as well as the contents of the Accreditation Plan and Accreditation Report are consistent with standard industry practices.

Integrated Modeling and Simulation

BACKUP

Integrated Modeling and Simulation

Typical Roles and Responsibilities Associated with M&S VV&A						
Role / Activity	User	M&S PM	Developer	V&V Agent	Accreditation Agent	SME
Define Requirements	Lead / Approve	Monitor	Assist	Review	Review	Assist
Define Measures	Lead / Approve	Monitor	Assist	Assist	Assist	Assist
Define Acceptability Criteria	Assist / Approve	Monitor	Assist	Assist	Lead	Assist
Plan M&S Development/ Modification[1]	Assist* / Lead / Approve	Lead* / Assist	Assist	Assist		
Develop V&V Plans	Review / Approve	Assist / Approve	Review	Lead	Assist	
Develop Accreditation Plan	Review / Approve	Assist		Assist	Lead	
Verify Requirements	Lead** / Approve	Monitor	Assist	Lead**	Assist	Assist
Develop Conceptual Model[2]	Assist / Approve	Monitor	Lead			Assist
Validate Conceptual Model	Assist / Approve	Monitor	Assist	Lead		Assist
Develop Design[3]		Monitor / Approve	Perform			
Verify Design	Approve	Monitor / Approve	Assist	Lead		Assist
Implement Design		Monitor / Approve	Perform			
Verify & Validate Data	Approve	Monitor	Assist	Lead		Perform
Verify Implementation (Code)	Approve	Monitor	Assist	Lead		Assist
Test Implementation	Approve	Monitor	Lead	Assist		Assist

Pre-decisional DRAFT

Integrated Modeling and Simulation

Typical Roles and Responsibilities Associated with M&S VV&A

Role / Activity	User	M&S PM	Developer	V&V Agent	Accreditation Agent	SME
Validate Results	Assist / Approve	Monitor	Assist	Lead		Assist
Prepare V&V Report				Perform		
Configure for Use	Assist* / Lead / Approve	Lead* / Assist	Assist			
Gather Additional Accreditation Info	Monitor	Assist		Assist	Lead	Assist
Conduct Accreditation Assessment	Monitor				Perform	Assist
Prepare Accreditation Assessment Rpt					Perform	
Determine Accreditation	Perform					
Prepare Accreditation Rpt					Perform	
Maintain Configuration Control		Perform				

Lead	Leads the task. Normally involves active participation from others
Perform	Actually does the task. Normally involves little active participation from others
Assist	Actively participates in task (e.g., conducting tests, providing information)
Review	Participation normally limited to reviewing results of task and providing recommendations
Monitor	Oversees task to ensure it is done appropriately but does not normally participate
Approve	Determines when an activity is satisfactorily completed and another can begin. Determines what activity should be pursued next (e.g., whether to continue on to the next scheduled activity or to return to a previous activity).

In general, this activity is led by the MS PM in new M&S developments and by the User in the modification of a legacy simulation.

This activity is led by the V&V Agent when available and by the User when the V&V Agent is not available at the beginning of the effort.

***[1] This activity refers to planning and scheduling of any M&S development, modification, or preparation*

[2] *This activity refers to development of new as well as modification of existing conceptual models*

[3] *This activity refers to development of new M&S designs as well as modification of existing M&S designs*

Pre-decisional DRAFT

Integrated Modeling and Simulation

V&V of Simulation Capability

ISSUE: Does the simulation do what it needs to do?

Accreditation Information			What is needed when risk is...			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
M&S Functional Breakdown and Description	Describes what the M&S actually does including: -M&S functions and relationships between functions. -Level of fidelity at which each function is modeled. -Function level input and output (I/O) and I/O relationships between functions. -Hardware, software and training needed to operate the model properly and interpret the output correctly.	- User / Developer Documentation	Any Source	Required	Required	- Document Check, or - Document Review	- Design Audit, or - Design Review, or - Design Walk-Through	- Review of Federation: o Objectives o Requirements o Conceptual Model o Scenario - Review of Federation Object Model (FOM) - Review of Federation Agreements
		- Design Documentation		Any one	Both	- Traceability Assessment		
		- Simulation Conceptual Model (SCM)						
List of Limitations Due to Assumptions and Errors	- Describes M&S assumptions and known errors, and assesses their impact on intended use. - Identification of assumptions and, or errors of each M&S function (or of the model as a whole) that are implicit or explicit in the model's design and/or coding, as well as the implications of these limitations on appropriate or acceptable uses of the simulation.	- Design Documentation	Desirable	Any one	Required	- Design Document Reviews		- Federation Design Review:
		- User Documentation				- User Document Reviews		- Federation Requirements Assessment
		- Configuration Management Database				- Review of Software Trouble Reports and Uncorrected Faults		- FOM Verification - Federation Agreement Verification
		- V&V Reports				- Proof of Correctness - Fault/Failure Analysis		- Federation Tests: o Connectivity o Syntactic Interoperability o Semantic Interoperability

Integrated Modeling and Simulation

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is..			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
M&S Dev'mt Process Description	- The development process description should include: · Description of the development paradigm and how it is being implemented (including the use of CASE tools). · A logical process for defining tracing, and testing requirements throughout development. · Configuration management during the development process. - Adequate provision for documentation of all of these activities.	- SW Development Plan (SDP)	Any Source	Required	Required	- Document Check, or - Document Review	- Design Audit, or - Design Review, or - Design Walk-Through	- Federation Audit, or - Federation Review, or - Federation Walk-Through
		- CM Plan		Any one	Either one	- CM Audit - CM Inspection - Traceability Assessment		
M&S Dev'mt Resources Description	- The resource description should include: · A description of the HW environment and the SW engineering tools that will be/were used. · Qualifications of the personnel who will/did code the SW and perform CM functions. · Identification of who will be/was responsible for production of key documentation and testing. · History of similar simulation development experience.	- Requirements Trace - Design Review - Peer Review - Logical V&V Review - Code Walk-Through - Problem / Change Request Logs	Desirable	Any one	Required	- Document Review - Desk Check - CASE Review - CMMI Review		

Integrated Modeling and Simulation

V&V of Software Correctness (2 of 6)

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is..			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
M&S Dev'mt Artifacts & Products	- M&S development artifacts should provide evidence (usually documentary in nature) that M&S SW development is actually being implemented in accordance with the guidelines and specifications called out in the SW development plan (or its equivalent).	- Design documentation (Documented Requirements and Simulation Conceptual Model) - Standard M&S Documentation	Desirable	Any one	Required	- Standards Test - Syntax Analysis - Semantic Analysis - Inspection	- Assessment of distributed simulation protocol compliance (e.g., DIS, ALSP, or HLA)	- Assessment of distributed simulation protocol compliance (e.g., DIS, ALSP, or HLA)
	- Documentary artifacts should comply with known (or acceptable) standards and practices for format, content, currency and applicability to the current versions of the SW.	- User's Manual/ Programmer's Manual - Configuration Management histories	Desirable	Any one	Required	- Standards Test - Document Review - CM Audit - CM Inspection		- Inspection of HLA documents against established standards, or - Inspection of DIS PDUs against established standards, or - Inspection of CTIA/TENA documents against established standards.

Integrated Modeling and Simulation

V&V of Software Correctness (3 of 6)

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is .			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
Initial V&V Results	Initial V&V results include all evidence that the code has been developed according to the design and is free of critical errors, including for example reports from: • Design reviews. • Code walkthroughs. • Regression testing on model changes. • Software testing. • Supplemental V&V efforts of previous simulation users.	- Requirements Trace	Any one			- Requirements Trace		- Verification of Federation Objectives to User Needs
		- Design Review Peer Review				- Design Review - Peer Review		- Verification of Federation Design to Federation Requirements
		- Logical V&V Review				- Logical V&V Review		- Verification of Federation Agreements
		Code Walk-Through	Any One	Any two	Any three	Code Walk-through		- Verification of New or Modified Federates - Validation of Federate Implementation
		Problem / Change Request Logs				Problem / Change Request Logs		- Federate Verification Test
		- SW Module Test Reports				- SW Module Test Reports		
		- Subsystem Test Reports				- Subsystem Test Reports		- Federation Verification Test - Verification of Federation Infrastructure
		- System Test Reports				- Static V&V Tests - Dynamic V&V Tests - System Tests		- Validation of integrated Federation results

Integrated Modeling and Simulation

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is .			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
CM Process Description	- The CM process description should include: • Description of the CM paradigm and how it is being implemented (including the use of CASE tools). • A logical process for controlling and managing requirements throughout the development. • Adequate provision for documentation of all CM activities.	- CM Plan - V&V Plan - Other management documentation that describes life-cycle activities. -	Any Two	Required	Required	- CM Audit - CM Inspection - Desk Check - CASE Review - Traceability Assessment - Document Review - Standards Review - Static V&V Tests - Dynamic V&V Tests - System Tests		- Validation of integrated Federation results

Pre-decisional DRAFT

Integrated Modeling and Simulation

V&V of Software Correctness (5 of 6)

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is .			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
CM Resources Description	− CM resource description should include: • A description of the CM environment and the CM tools that will be/were used. • Qualifications of the personnel who will/did perform CM functions. • Identification of who will be/was responsible for production of CM documentation.	− Management Plans	None	Desired	Desired	− CM Audit − CM Inspection − Desk Check − CASE Review		
CM Artifacts and Products	− Artifacts that provide evidence (usually documentary in nature) that CM is actually being implemented in accordance with the guidelines and specifications called out in the software development or CM plan (or its equivalent). − Documentary artifacts should comply with known (or acceptable) standards and practices for format, content, currency and applicability to the current versions of the software.	− CM Database Status Reports		Any One	Any Two	− CM Inspection or Audit		
		− System Change Requests (SCRs)				− Functionality Testing − Performance Testing		
		− System Trouble Reports (STRs)						
		− CCB And User Group Meeting Minutes				− Reviews		
		− Existing Design Documentation				− Document Reviews − Standards Reviews		

Integrated Modeling and Simulation

V&V of Software Correctness (6 of 6)

ISSUE: How much confidence do you have in the correctness of the software?

Accreditation Information			What is needed when risk is .			Associated V&V Activity / Artifact for...		
Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
V&V Results From Later Usage (e.g., different applications, or different M&S versions)	- Artifacts from successive V&V activities to demonstrate the M&S continues to meet user's evolving needs and requirements.	- Software Problem Change Request (SPCR) Logs		Any one	Any Two	- Audits - Functional Tests		
		- Alpha or Beta Test Reports on new requirements testing and regression testing		Either one coupled with above CM info	Either one coupled with above CM info	- Alpha or Beta Tests - Regression Tests		- Verification of Federation Objectives to User Needs
		- V&V Reports for specific simulation version	Note 1	Note 1	Note 1	- Static V&V Tests - Dynamic V&V Tests - System Tests - Comparison Tests - Proof of Correctness		- Federate Verification Test - Federation Verification Test - Verification of Federation Infrastructure - Validation of integrated Federation results
		- Similar application / usage histories	Note 2			- Inspection - Induction - Inference		

Note 1: If the scope and depth of the specific verification results equates to the scope and depth of development V&V required for a particular level of risk, this element can be substituted for all the information items dealing with the quality of the software in this issue

Note 2: This information alone can be used as evidence of sufficient quality for low risk applications (it can replace all other information items for this issue.

Integrated Modeling and Simulation

V&V of Fitness of Purpose

ISSUE: What does the simulation need to do?

Items(s) Desired	Accreditation Information		What is needed when risk is...			Associated V&V Activity / Artifact for...		
	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
Application Description	- Describes what the M&S is intended to do, how it achieve this state, and with what data.	- User-defined problem statement. - Intended use statement.	Verbal description is sufficient	Required	Required	- Document Check, or Document Review	- Design Audit, or Design Review, or Design Walk-Through	- Verification of Federation Objectives to User Needs - Verification of Federation Design to Federation Requirements
M&S Requirements		- User-defined objectives and requirements.	Verbal description is sufficient	Desired	Required	- Design Document Reviews - Traceability Assessment		- Verification of Federation Agreements - Verification of New or Modified Federates - Validation of Federate Implementation
Input Data Metadata		- Data QA templates, data producer documentation	Verbal description is sufficient	Desired	Required	- User Document Reviews - Review of Software Trouble Reports and Uncorrected Faults - Proof of Correctness - Fault/Failure Analysis		
Risk Analysis Results	- Describes the risks of M&S use in terms of impact and probability of occurrence.	- Risk Assessment Report for intended application	Informal	Formal document	Formal document	- Probability and Impact Evaluation (PID)		

Integrated Modeling and Simulation

V&V of Simulation Usability

ISSUE: Do you have confidence that the simulation is being run properly?

Accreditation Information | **What is needed when risk is ..** | **Associated V&V Activity / Artifact for...**

Items(s) Desired	Item Description	Typical Sources	Low	Moderate	High	Legacy M&S	New M&S	Federation or SoS M&S
Evidence of suitability of HW and operating system (portability).	- Describes usability of the simulation and its portability across platforms, operating environments, etc.	- User documentation	Required	Required	Required	- Portability Assessments - Data Flow Tests - Data Interface Tests - Desk Checks		
		- Test results						
Operator Qualification	- Describes qualifications of the operators/users executing the M&S as part of the problem solution process.	- Biographies and interviews with the operators						

ISSUE: Can you convince others of your interpretation of simulation outputs?

| Analyst qualifications | - Describes qualifications of analysts using M&S data as part of the problem solution process. | - Analyst biographies or interviews
- Prior accreditation assessments. | Required | Required | Required | - Desk Checks | | |
| Demonstrate Acceptability of data pre- and post-processors | - Describes suitability of the pre-processors that condition input data, and the post processors that reduce the output data as part of the problem solution process. | - Documentation that lists tools and compatible tools
- User / Operator documentation for tools and utilities | Desired | One | Two | - Execution Monitoring
- Execution Profiling
- Execution Trace | | |

Pre-decisional DRAFT

Integrated Modeling and Simulation

V&V of Overall Data Correctness

What is needed when risk is . . .

Information Desired	Typical Sources	Low	Moderate	High
ISSUE: How much confidence do you have in the quality and suitability of input data obtained from outside sources?				
Data Quality Profile	Data Quality template, data producer metadata, database archives	– Either one. Depth of information determined at database level	– Either one. Depth of information determined at database level	– Either one. Depth of information determined at database level
Independent data quality assessments	Test Plans, Laboratory Procedures, Calibration Records, Test Reports Surveys, Monitoring Operations In Data Collection Plans, Reports, Etc.			
Data manipulation/ transformation verification results	Data Verification Reports Data Transformation Validation Reports Data V&V Techniques	Required at cursory level	– Required	– Required
ISSUE: How much confidence do you have in the quality and suitability of self-generated input data?				
Description of Data Quality Assurance process for self-generated data	Test Plans, Laboratory Procedures, Calibration Records, Test Reports Surveys, Monitoring Operations In Data Collection Plans, Reports, etc.	– **Required. Depth of information determined at database level**	– **Required. Depth of information determined at database level**	– **Required. Depth of information determined at database level**
Descriptions of Data Quality Assurance resources for self-generated data	Data Verification Reports Data Transformation Validation Reports Data V&V Techniques Used	– **Required at cursory level**	– Required	– Required

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Database Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
ISSUE: How much confidence do you have in the quality and suitability of input data obtained from outside sources?				
Description including meaning of exceptions, nulls, uncertainties	An overall textual characterization of the database including: – Discussion of its intended range of appropriate uses and any constraints on its intended use – Discussion of the meaning of exceptions, nulls, and uncertainties within the database	Either one. Depth of information determined at database level	Either one. Depth of information determined at database level	Either one. Depth of information determined at database level
Independent data quality assessments	– Test Plans, Laboratory Procedures, Calibration Records, Test Reports – Surveys, Monitoring Operations In Data Collection Plans, Reports, Etc.			
Data manipulation/ transformation verification results	– Data Verification Reports – Data Transformation Validation Reports – Data V&V Techniques	Required at cursory level	Required	Required
ISSUE: How much confidence do you have in the quality and suitability of self-generated input data?				
Description of Data Quality Assurance process for self-generated data	– Test Plans, Laboratory Procedures, Calibration Records, Test Reports – Surveys, Monitoring Operations In Data Collection Plans, Reports, etc.	Required. Depth of information determined at database level	Required. Depth of information determined at database level	Required. Depth of information determined at database level
Descriptions of Data Quality Assurance resources for self-generated data	– Data Verification Reports – Data Transformation Validation Reports – Data V&V Techniques Used	Required at cursory level	Required	Required

Pre-decisional DRAFT

37

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Database Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Description including meaning of exceptions, nulls, uncertainties	An overall textual characterization of the database including – Discussion of its intended range of appropriate uses and any constraints on its intended use – Discussion of the meaning of exceptions, nulls, and uncertainties within the database	Required	Required	Required
Access requirements	Information about the requirements for gaining access to the database including – Owning Agency, POC Access Information – Restrictions that apply to Access and Use – Copyright, Foreign Distribution Requirements, And Constraints – User Requirements for SW, HW, Pre- And Post-Processing, etc.	Desired	Required	Required
Resolution and rationale	Description of the overall level or resolution of the data in the database including: – Reasons for choosing the level with respect to the stated purpose of the database, its design, source, relationship to other databases – Characterization of the database in terms of resolution, consistency	Desired	Required	Required
Usage (who, when, for what, with what model)	– The history of the database, including a POC for each instance of use and a description of what the database was used for (linked to V&V audit trail)	Desired	Required	Required

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Database Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
V&V Audit Trail	– History of quality assessment efforts applied to the database including records of V&V results. Should be linked to the usage history metadata above and to the metadata for the V&V audit trail at the data element and data value.	Required	Required	Required
Classification	– Simple statement about the security level of the database.	Required	Required	Required
Release Authority	– Organization/Agency and/or POC authorized to release all or part of the database for use		Desirable	Desirable
Accuracy	– Discussion of the degree of agreement between a datum and source assumed to be correct (real world).		Desirable	Required
Completeness In Features and Attributes	– Discussion of how the database satisfies all data content demands and requirements.			
Currency	– Discussion of how up-to-date the database is		Required	Required
Data Sources	– Discussion of where the source information contained within the database came from (immediate source and original source) including agency/organization/POC, etc.		Required	Required
Source Credibility	– Discussion of the credibility of the agency/organization/POC providing the data in the database, identifying who has certified the immediate and original data sources as credible		Required	Required
Descriptions of Data Processes Used	– Discussion of the processes that are used to derive, generate, collect, and transform the data and metadata in the database		Desirable	Required

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Database Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Version History	– Explicit version documentation showing which agents revised the database at which times and what kinds of changes they made, including descriptions of changes to structure, content, or meaning of both data and metadata at the conceptual level. An official record of changes to a database by the agency or organization that owns and has responsibility for maintaining it.	Desirable	Desirable	Required
System Specification and Design Document	– Formal description of the database structure and content		Desirable	Required
Standards	– Compliance with international, national, DoD, or M&S community standards (e.g., DDDS)		Desirable	Required
Specific Data Sets	– Instances/sessions of the database. Discussion of each data set for which the given database design is used. Each instance of a database may be static or dynamic, and this aspect should be documented as part of its description.		Desirable	Required
Overall Database Status	– Concise statement of the condition of the database, indicating whether it is in transition, how stable it is, and what expected future changes will affect it, including configuration management information that explains how versions are maintained and by whom, and references to descriptions of any standard methodology of software used for version control.		Desirable	Required
Description / Rationale for Structure and Design	– A textual characterization of the database design and structure and a discussion of their rationale, relating them to the intended purpose and use of the database. It should include such overall aspects as the language and format. The rationale serves as consistency check against the discussion of intended use.		Desirable	Desirable

Pre-decisional DRAFT

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Database Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Global Relationships to Other Databases	– An explicit description of the overall relationship of this database to any others. It should explain any semantic and/or historical relationships between this database and any others, making clear whether the relationship is expected (or required) to continue to hold true.			
Reproducibility	– Ability of the producer to provide exact replications of a previously supplied database (new database instance)			
Cross Data Element Distribution Measurement Information	– A description of statistical checks to be applied to distributions of values across different data elements in the database. (Metadata for such checks applied to distributions of values of single data elements should be specified at the date element level.)			
Rationale for using the processes	– Discussion of the reasons for choosing each process used for the derivation, generation, collection, and transformation of data (and metadata) within the database.			
Owners of the processes (development, maintenance, execution)	– Agents responsible for choosing and developing the processes used for the derivation, generation, collection, and transformation of data (and metadata) within the database, including agency/organization, POC, etc.			
Update cycle information	– Statement of how often, how regularly, and how extensively the database is expected to be updated. Overlaps with 'currency' metadata, but the emphasis here is on giving an overview of when, how, and by whom the database is revised or reissued, rather than on how current the information within it may be at any given time.		Desirable	Desirable

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Data Element Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Description including meaning of Exceptions, Nulls, Uncertainties	An overall textual characterization of the semantics of the data element, including a discussion of what it is intended to represent and what it is not. Includes a textual characterization of the meaning of nulls or any exceptional, special, or unknown values of this data element		Desirable	Required
Degradation Information	The 'mode' in which values of a data element are expected to degrade over time: some values become continuously less accurate or less meaningful as they age, whereas others remain entirely valid until they 'expire', i.e., when some event changes the reality which they represent.			Required
Aggregation, Derivation, or Transformation Information	Whether and how values for this data element are derived from other data, including a discussion of any grouping or other derivation method used to generate this data element, and any other data values used in this derivation, or any transformations that are applied in generating this data element			
Resolution and Precision	The level of detail and number of significant digits in numerical values of this data element, including any representation issues (such as precision limits imposed by field-length or encoding).		Desirable	Required
V&V Audit Trail	A high-level history of quality assessment efforts applied to the data element, allowing certification results to be recorded. This should be linked to the usage history metadata above and to the metadata for the V&V audit trail at the database and data value			

Pre-decisional DRAFT

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Data Element Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Entity Name	– The label of an entity; must be a noun or noun phrase with the entire phrase connected by hyphens; must accurately reflect its characteristics (attributes), especially its domain.			
Definition Text	– The narrative description of what an entity is.			
Standard Data Element Name	– The label of an attribute, comprised of a minimum of an entity and generic element; may contain property modifier(s) providing additional descriptions; may utilize generic data; must be a noun or noun phrase and accurately reflect the characteristics (metadata) of the attribute, especially domains.			
Source or sources and deconflicting processes and rationales	– Where the source information contained within the data element came from (immediate source versus original source) including agency/organization, POC, etc. Includes a qualitative, textual discussion of the 'goodness' of the database including information about the agency/organization, POC, etc making the credibility assessment. It should include a discussion of who has certified the certification official as credible.			
Changes or modifications of source element and effect on this data element	– The update-cycle metadata for the database as a whole, focusing on the revision of a particular data element, which may be different for different data elements within the database. Different levels of revision may occur, corresponding to more or less complete revisions by more or less authoritative sources or agents.			

Integrated Modeling and Simulation

V&V of Overall Data Correctness: Data Element Level

Information Desired	Typical Sources	What is needed when risk is . . .		
		Low	Moderate	High
Release Authority	– Organization / agency / POC authorized to release the data element.			
Process Control Data	– Historical record of how the generation of the data element was controlled, including descriptions of process modeling methodology, or external descriptions of the process in some appropriate form or publication.			
Audit Trail of Changes to Element	– History of any changes to the definition of this data element; i.e., its type, domain, units, or meaning, including times and sources of any such modifications and the changes themselves.			
History of Changes or Modifications	– Explicit version documentation showing which agents revised the data element at which times and what kinds of changes they made, including descriptions of changes to structure, content, or meaning of both data and metadata at the conceptual level. An official record of changes to a data element by the agency or organization that owns and has responsibility for maintaining it.			